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EXPERIMENTAL RESULTS OF A LOW COST FLEXIBLE GRIPPER

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ABSTRACT

In this study, the experimental results of a novel low cost flexible gripper are presented. This novel flexible gripper has been designed, constructed and tested. The gripping experiments have been documented and the movement of the flexible band has been numerically simulated using tenth degree polynomials. The flexible gripper was able to pick up successfully small objects of triangular, rectangular and circular forms with a maximum weight of 500gr.

***Index Terms* –** Low cost, Flexible, Multipurpose, Gripper

1. INTRODUCTION

Object manipulation is one of the most difficult tasks in robotics. Picking up small objects of different sizes and forms normally requires different kinds of grippers. Flexible manipulator control has been researched by many groups. Kojima and Hiruma use the genetic algorithm to obtain the optimal trajectory for a flexible robot arm [1]. Ge, Lee and Zhu developed a joint PD controller using Lyapunov's direct method to improve the tip regulation performance of a flexible manipulator [2]. Luo, Zhang, Sun and Yang proposed a kinematic compensation to correct the tip position errors of a four DOF macro-micro manipulator systems caused by deformation and vibration [3]. In contrast, there are very few studies related to flexible grippers. Choy, Han, Kim and Cheong presented a robust force tracking control of a flexible gripper using shape memory alloy actuators [4].

In this study, the experimental results of a novel low cost flexible gripper are presented.

2. DESIGN OF THE LOW COST FLEXIBLE GRIPPER

The objective of this low cost design is to develop a multifunctional gripper that could be able to handle objects of different shapes and sizes. By the use of a flexible plastic band, the proposed gripper is able to pick up small objects of triangular, rectangular or circular forms. Figure 1 shows the details of the structure of the experimental flexible gripper. The structure and the electric motor supports are made of

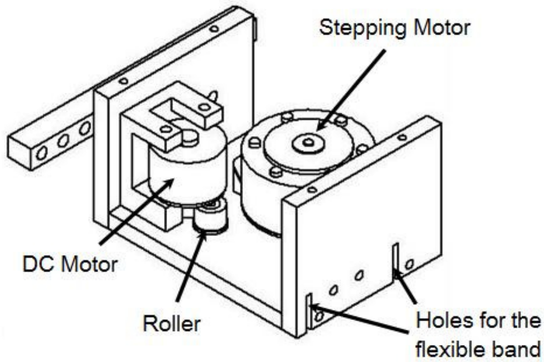


Figure 1: Structure of the flexible gripper

aluminum. The flexible gripper is actuated by the use of a stepping motor. A small DC motor is used as an electric current sensor and two rubber rollers guide the movement of the flexible plastic band. The structure of the gripper without the flexible band is approximately 90mm long, 64mm wide and 50mm high. The distance between the holes for the flexible band is 38mm and the plastic flexible band has an effective usable length of 260mm. Figure 2 shows the upper and side diagrams of the gripper structure. The electric motors are controlled with the use of an Atmega8L microcontroller.

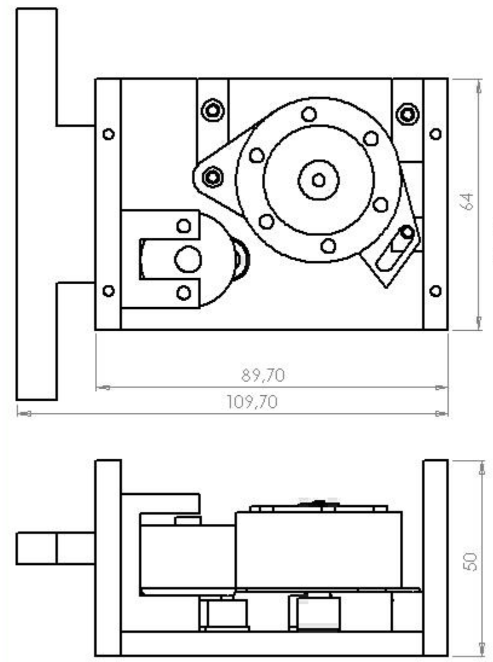


Figure 2: Diagrams of the flexible gripper

3. PRELIMINARY EXPERIMENTAL RESULTS

Preliminary experimentations were made with a flexible gripper prototype. Figure 3 shows the experimental device and the measuring parameters for the experiments without load. The distance between the holes for the flexible band and the length of the flexible band (P) determined the maximum length ($L_{\max}$) and width ($W_{\max}$) of the gripping area.

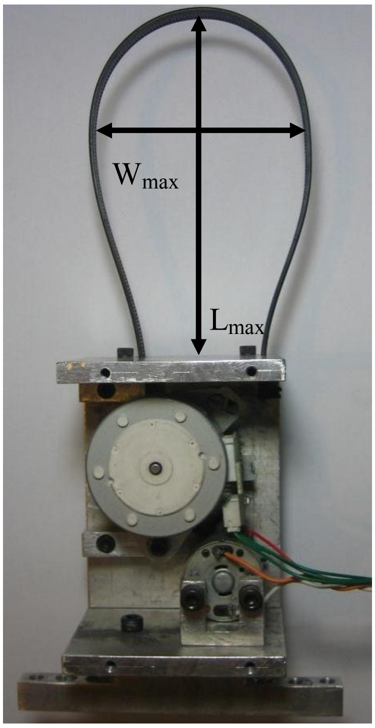


Figure 3: Experimental device and measuring parameters

The maximum experimental results for $P = 26cm$ were $L_{\max} = 10.7cm$ and $W_{\max} = 6.7cm$.

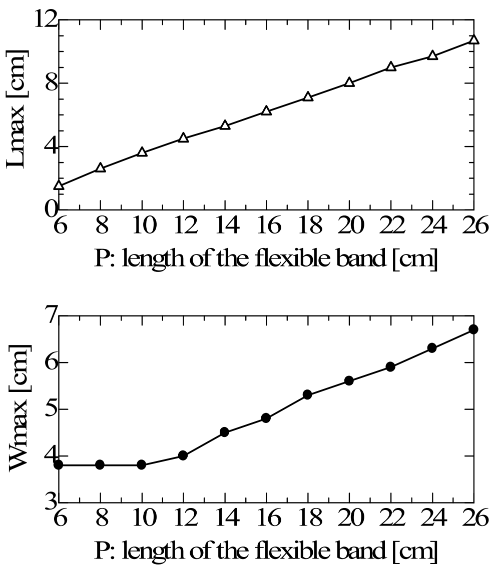


Figure 4: Preliminary experimental results

Figure 4 shows the preliminary experimental results of the relations between the length of the flexible band (P) and the maximum length $L_{\max}$ and the maximum width $W_{\max}$ of the gripping area.

4. NUMERICAL SIMULATION

A numerical simulation was developed with data taken from the experiments. A tenth degree polynomial was used to track the positions of 14 points along the flexible band. The distance between these points on the band was 2cm.

By the use of equations (1) and (2), the position of the point n in the band for the length P was calculated.

$$\begin{aligned} X_n = a_0 + a_1 P + a_2 P^2 + a_3 P^3 \\ + a_4 P^4 + a_5 P^5 + a_6 P^6 \\ + a_7 P^7 + a_8 P^8 + a_9 P^9 + a_{10} P^{10} \end{aligned} \quad (1)$$

$$\begin{aligned} Y_n = b_0 + b_1 P + b_2 P^2 + b_3 P^3 \\ + b_4 P^4 + b_5 P^5 + b_6 P^6 \\ + b_7 P^7 + b_8 P^8 + b_9 P^9 + b_{10} P^{10} \end{aligned} \quad (2)$$

Figure 5 presents eleven graphics of the numerical simulation for values of P from 6cm to 26cm in intervals of 2cm. The numerical simulation helps to understand the movement and position of the flexible plastic band for the different values of the length P .

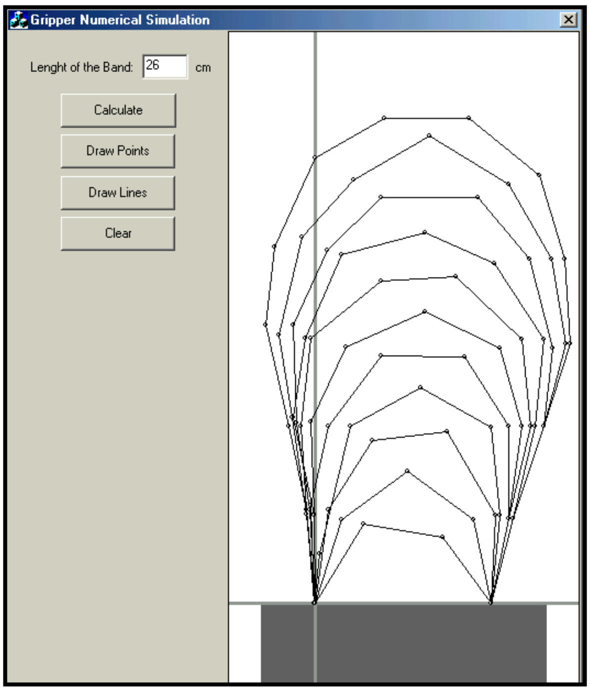


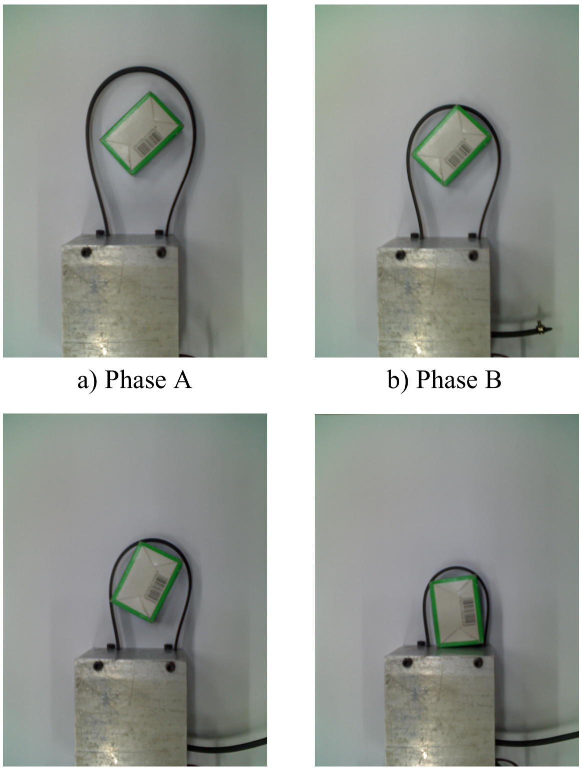
Figure 5: Numerical simulation

5. EXPERIMENTAL RESULTS

Different experiments were made to understand the gripping capabilities of the flexible gripper. The first group of experiments was related to the gripping capabilities of small objects of different sizes and shapes. The second group of experiments was related to the holding capabilities of heavy objects.

5.1. Gripping capabilities

The gripping capabilities of the flexible gripper were tested by picking up different objects one at a time. The flexible gripper was able to lift small objects of triangular, rectangular and circular forms with a maximum weight of 500gr.



a) Phase A　　b) Phase B

c) Phase B　　d) Phase C

Figure 6: Gripping phases

Three different phases were observed in the gripping experiments. On the phase A, the object was placed in the gripping area and the flexible band started to close until the band makes contact with the object. During phase B, the object was dragged to the gripper structure with the flexible band. On the phase C, the object was secured between the flexible band and the structure of the gripper. Figure 6 shows an example of picking a rectangular prism form object in the different three phases.

5.2. Holding capabilities

For the holding experiments, the flexible gripper was installed on a robotic arm. The robotic arm was a Scorbot model ER-IX. These holding experiments consisted on holding a soft drink PET bottle in different positions. The object had an approximately weight of 450gr. Different holding positions were tested. The gripper was able to hold the object in position in spite of the movements made by the robotic arm. Figure 7 shows the detail of the flexible gripper installed on the robotic arm holding the object.

Figure 7: Flexible gripper installed on the robotic arm Scorbot EX-IX

6. CONCLUSIONS

The novel flexible gripper was able to pickup small objects and was able to hold heavy objects in position in spite of the movements made to the gripper structure. The manufacturing cost of the prototype including the microcontroller was below eighty euros.

7. REFERENCES

[1] H. Kojima, T. Hiruma, "Evolutionary Learning Acquisition of Optimal Joint Angle Trajectories of Flexible Robot Arm", Journal of Robotics and Mechatronics, Fuji Technology Press, Vol.18, N.1, pp.103-110, 2006.

[2] S. Ge, T.H. Lee, G. Zhu, "Improving Regulation of a Single Link Manipulator with Strain Feedback", IEEE Transactions on Robotics and Automation, Vol.14, N.1, pp.179-185, 1998.

[3] L. Luo, Y. Zhang, Z. Sun, T. Yang, "Global Optimization of Motion Planning for a Flexible Macro-micro Manipulator System Using Estimation of Distribution Algorithm", Proceedings of the International Conference on Artificial Intelligence, 2006.

[4] S. Choy, Y. Han, J. Kim, C. Cheong, "Force Tracking Control of a Flexible Gripper Featuring Shape Memory Alloy Actuators", Mechatronics, Elsevier, Vol.11, N.6, pp.677-690, 2001.